



African vegetation studies: introduction to a Special Collection

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Abstract

Abstract: This editorial introduces the Special Collection of “African Vegetation Studies”. The collection includes seven research papers from four African countries. One paper examines the impact of traditional agro-ecosystems on plant diversity in Morocco. In Benin, one research paper focuses on vegetation associations in a biosphere reserve, and another is on land cover changes on inselbergs. In Namibia, one paper provides a syntaxonomic description of the Karstveld vegetation, while another models potential vegetation changes along a south-north rainfall gradient. Two papers present research on vegetation classification and descriptions of two natural areas in South Africa, namely the Tankwa Karoo National Park and the Telperion Nature Reserve. The collection demonstrates that there are important classification studies ongoing in different parts of the continent to better understand the diversity and complexity of African vegetation. At the same time our mini-review of the current status of vegetation classification and vegetation-plot databases in Africa highlights that much work remains to be done to achieve a comprehensive and internationally consistent vegetation classification for the countries of Africa, which would be beneficial for land use management, biodiversity conservation and ecological research.

Abbreviations: EVA = European Vegetation Archive; EVS = European Vegetation Survey; GDP = Gross Domestic Product; IAVS = International Association for Vegetation Science; IAVS-AS = IAVS Regional Section for Africa; VCS = Vegetation Classification and Survey.

Keywords

Africa, editorial, International Association for Vegetation Science (IAVS), phytosociology, remote sensing, vegetation classification, vegetation map, vegetation-plot database

Introduction

Africa, the world's second largest continent, is bordered by the Mediterranean Sea, the Red Sea, the Indian Ocean, and the Atlantic Ocean and is almost equally divided by the equator. It covers an area of 30.3 million km² (including adjacent islands such as Cape Verde, Madagascar, Mauritius, Seychelles, and Comoros). It is also the second most populous continent after Asia. With 53 countries, Africa has more countries than any other continent in the world.

Africa is characterized by a great diversity of vegetation types and ecosystems. White (1983) classified 16 natural vegetation types mainly based on their physiognomy. These vegetation types include forest, woodland, bushland and thicket, shrub land, grassland, wooded grassland, desert, Afro-alpine vegetation, scrub forest, transition woodland, scrub woodland, mangrove, herbaceous fresh-water swamp and aquatic vegetation, halophytic vegetation, bamboo, and anthropogenic landscape (White 1983; Mengist 2020). However, due to several factors including increasing anthropogenic pressure, climate change, and industrialization, there are vegetation changes over time. These changes have been exacerbated by a rapidly growing human population across the continent, resulting in a high demand for food (and thus agricultural land), construction materials, energy, and other raw materials. These factors led to changes in the various vegetation types, resulting in an update of the vegetation types of Africa by Mayaux et al. (2003), classifying the vegetation into five main types: forest, woodlands and shrublands, grasslands, swamp and mangrove vegetation, and agricultural lands. In any case, all existing classifications of the vegetation of Africa as a whole remain at a very coarse level, hardly suitable for regional planning and conservation prioritization. Fine-scale classification of vegetation does not have a strong academic tradition in Africa except in a few countries.

Although some research on African vegetation has been published, data on the African flora and vegetation remains relatively poorly documented compared to other regions such as Europe and the Americas (Küper et al. 2006). This poor representation of Africa is due to several factors. First, data availability, data access, and language barriers hamper efforts to build databases on African vegetation. Second, low budgetary allocations for science in most African countries are well documented and serve as a major barrier that directly affects research focus and the data availability (Christie 2019; Krishna 2020; Adepoju 2022). For example, in 2006, African Union member states committed to spend 1% of their Gross Domestic Product (GDP) on research and development. But by 2019, the continent's funding was only 0.42% (range of 0.1 to 0.5%) of the GDP, in sharp contrast to the global average of 1.7% and against UNESCO's recommendation of at least 1% (Christie 2019; Krishna 2020; Adepoju 2022). By comparison, in 2020, Latin America and the Caribbean invested 0.62% of their regional income in science, compared to 3.32% in North America and to 2.28 in the countries of the European Union (World Bank 2020). Third, political

instability in some regions of Africa also is an obstacle to the sustained and consistent advancement of scientific research. Thus, to better understand the extraordinary diversity of African vegetation and all its habitat types, there is a need to improve vegetation survey techniques, broaden the scope of sampling across the continent and improve collaboration among scientists to address data challenges. This will strengthen communication among vegetation scientists from different regions and provide the scientific basis for national and international nature conservation initiatives and formulation of the best management practices. However, a comprehensive and consistent classification system is still far from being fully realized.

In 2021, the journal *Vegetation Classification and Survey* (VCS) and the African Section of the International Association for Vegetation Science (IAVS-AS) partnered to launch a Special Collection dedicated to "African Vegetation Studies". The aim of this Special Collection was to provide new case studies of vegetation classifications across the African continent. The vegetation typologies could be of any kind, for example based on vegetation plots or remote sensing data. Likewise, the papers could develop a new classification system for a certain vegetation type in a particular region, or use an existing vegetation typology in applied research, e.g. related to global change. This editorial begins with an overview of the current knowledge on vegetation types in Africa and the available databases, followed by summaries of the articles in the Special Collection, and ends with conclusions and future perspectives.

Current state of vegetation classification in Africa

At the continental scale, only rather coarse physiognomic classifications exist for Africa, namely the one by White (1983). Recently, a remote-sensing based map of even coarser vegetation types was published by Mayaux et al. (2003). Probably the most recent and most detailed global map of biomes is that of Loidi et al. (2022). This study recognized five biomes and nine sub-biomes on the African continent. Based not on vegetation but on vascular plant flora, Linder et al. (2005) classified all of Africa into phytochoria. More recently, Marshall et al. (2021) divided tropical Africa into 19 clusters (floristic provinces). Both sources could also provide a useful framework for vegetation studies.

Studies at finer physiognomic scales, or even at community level based on vegetation plots, exist only in some regions of some countries. Below we provide a rough overview of the current state in four broad regions of Africa where at least one of the authors has some insight. We have excluded Central Africa and Madagascar, where we are not aware of any classification study (except Lebrun 1947 from the Democratic Republic of Congo). This may be our personal bias, but it coincides with the fact that these two regions are also largely without internationally available vegetation plot data (see next section).

Northern Africa

The francophone countries of NW Africa (Morocco, Algeria) have a considerable tradition of phytosociological vegetation classification, mainly carried out by researchers from France, but sometimes also from other European countries. They mostly focused on the climax vegetation, i.e. forests and steppes (e.g. Quézel 1956; Quézel and Barbero 1981, 1986, 1989; Quézel et al. 1987, 1988). In consequence, Morocco is probably the only country in Africa to date that has a comprehensive overview of the syntaxa on its territory (Fennane 2003), but even this is not particularly up to date. The Canary Islands, geographically part of Africa but politically part of the European Union, are probably the best surveyed region of Africa in terms of plant community classification (e.g. Rivas-Martínez et al. 1993). Interestingly, some plot-based vegetation typologies have also emerged in Egypt in recent years, namely for the Sinai (Hatim et al. 2021) and for a mountainous region in the south (Abutaha et al. 2020). Recently, some comprehensive plot-based studies of European vegetation types have also included data from the northernmost (Mediterranean) part of Africa (Marcenò et al. 2018, 2019).

Western Africa

Major vegetation studies conducted in the West African region include the BIOTA (Biodiversity Monitoring Transect Analysis in Africa) West project, the SUN project and the UNDESERT project, which have resulted in numerous publications on the vegetation of West Africa and vegetation databases such as the West African Vegetation (<http://www.westafricanvegetation.org/menu/home.aspx>) and the West African plants photo guide (<http://www.westafricanplants.senckenberg.de/root/index.php>). A comprehensive description of the vegetation of West Africa was provided by Hahn-Hadjali et al. (2010), who recognized four vegetation zones and fifteen vegetation types. Several studies have focused on providing descriptions of phytosociological plant communities in specific locations such as the inselberg plant communities of Burkina Faso (Tindano et al. 2024), the woody plant communities of the Comoe-Leraba Reserve (Gnoumou et al. 2020), the occurrence of herbaceous plant communities in West African savannas (Zerbo et al. 2018), among others. Even more specific studies have been conducted, such as a study focused on *Piliostigma* associations (Barthelemy et al. 2015).

Eastern Africa

East Africa does not have a strong tradition of vegetation classification, and we are not aware of any country with a comprehensive overview of fine-scale vegetation types. Recently, however, some specialized studies of wetlands have been published (Alvarez 2017; Behn et al. 2022). Such vegetation has been aligned to classes originally described for

Europe as *Phragmito-Magnocaricetea* and *Potamogetonetea*, but now recognized globally. In contrast, the class *Oryzetea sativae*, described for weedy vegetation in rice fields, has also been applied to pioneer vegetation with a likely pan-tropical distribution. These revisions were based on earlier classifications made by Lebrun (1947) for the vegetation of the Democratic Republic of the Congo. Other work has examined the ecology of plant communities in Afro-montane wetlands in Tanzania (Deil et al. 2016) and forests in the Kenyan Rift Valley (Fujiwara et al. 2014). The systematic collection of data in specialized databases (e.g., Alvarez et al. 2021) and the refinement of new statistical assessments represents important advances toward a general review of vegetation in these regions and elsewhere in Africa.

Southern Africa

For South Africa, Lesotho and Eswatini, a comprehensive and detailed vegetation typology with accompanying maps has been published by Mucina and Rutherford (2006). These maps have been regularly updated and refined since then. However, the work provides the description and distribution of major habitat types with their broad vegetation units but is not based on formal plot-based vegetation classification. There is, however, a long tradition of plot-based Braun-Blanquet-type assessment of vegetation in South Africa, resulting in a significant amount of plot-based vegetation data but formal classifications are largely lacking (Brown and Bredenkamp 2018, but see Luther-Mosebach et al. 2012). There are many local to regional classification and mapping studies, mainly within protected areas of the country, such as in the northeastern South Africa (Bezuidenhout 1993; Brown et al. 1997; Morgenthal and Cilliers 1999; Van Staden et al. 2021), of the more arid western South Africa (Van der Merwe et al. 2008a, 2008b; Luther-Mosebach et al. 2012; Bezuidenhout and Brown 2021), of the central grasslands (Kay et al. 1993; Brand et al. 2011), mountains and inselbergs (Brand et al. 2009; Barret et al. 2024) and of ruderal vegetation in northwestern South Africa (Cilliers and Bredenkamp 1998, 1999a, 1999b).

A similar approach was used for a vegetation map of Namibia by Giess (1971). A country-wide vegetation map for Namibia based on formal vegetation classifications is in progress (Strohbach and Jürgens 2010), and first large-scale approaches have been published (Jürgens et al. 2013). In Botswana, vegetation classifications have mainly been carried out at local scales (e.g. Murray-Hudson et al. 2011; Tsheboeng et al. 2016; Sianga and Fynn 2017; Lori et al. 2019). None of these studies in Botswana, except for Sianga and Fynn (2017), produced a vegetation map but instead described phytosociological plant communities in different localized areas in the Okavango Delta (Murray-Hudson et al. 2011; Tsheboeng et al. 2016) and Khutse Game Reserve (Lori et al. 2019). Currently, there are no published studies on vegetation mapping at a country-wide scale. Therefore, a formal comprehensive

vegetation map is still needed in Botswana. Even fewer classification studies are known from Angola, with Rev-
ermann et al. (2018) on the forests and woodlands of the
Cubango Basin being one of the exceptions.

Databases

Since 1997, several datasets on plant collection records in Africa have been established (Linder 1998, 2001; Lovett et al. 2000; La Ferla et al. 2002). Since 2003, these datasets have been merged with others into a single Biogeographical Information System on African Plant Diversity (BISAP) (Linder et al. 2005; McClean et al. 2005; Küper et al. 2006).

In contrast, the availability of vegetation plots in databases is rather low. When the global vegetation plot database sPlot 2.1 (Bruehlheide et al. 2019) was released, the African continent was poorly represented, especially compared to Europe, North America and Australia. Since then, sPlot has made great efforts to increase the data coverage in the Global South (G. Damasceno, pers. comm.). In the current working version of sPlot 4.0, only 45,202 out of a global total of 2,531,784 plots are from African countries (G. Damasceno, pers. comm.). This represents 1.8%, while Africa covers 22.5% of the ice-free surface of the Earth. A total of 30 regional databases contributed vegetation-plot data from 38 African countries, but there is still a considerable number of African countries without a single vegetation plot in sPlot. The spatial coverage of available vegetation plots in the sPlot database largely reflects the pattern of the articles included in this Special Collection (see below) and the state of vegetation studies in Africa summarized in the previous section. The only two countries with relatively good coverage by vegetation plots (in sPlot), both in terms of area and habitat types, are Namibia and Morocco. It is promising that several new regional vegetation-plot databases have emerged in Africa in recent years, such as the Coastal Forests database of Kenya (Fungomeli et al. 2020), SWEA-Dataveg (Alvarez et al. 2021) and the Vegetation Database of Sinai in Egypt (Hatim et al. 2021). South Africa has a National Vegetation Database (NVD) consisting of more than 46,000 plot-based data, curated jointly by the National Botanical Institute and the University of Stellenbosch. The NVD is also registered in the Global Index of Vegetation-Plot Databases (GIVD; Dengler et al. 2011) but has not yet joined sPlot.

Content of the Special Collection

The VCS Special Collection comprises seven articles from four countries in northern, western and southern Africa (Figure 1). The methodological approaches ranged from detailed phytosociological studies based on vegetation plots to coarse vegetation classifications using formations derived from remote sensing. The studies are introduced in the following.

Northern Africa

Chakkour et al. (2023) conducted research on the plant diversity of traditional agroecosystems in mountainous regions of Morocco. The authors placed 94 relevés in six study areas and identified a total of 209 different plant species. The data revealed that the vegetation, although influenced by agricultural activities, showed some affinity to the *Brometalia rubenti-tectorum* order. A total of 46% of the species were agricultural species while 31% were typical of natural and semi-natural areas. Wild grasses showed a high constancy and dominance in all the studied areas. The high number of perennial species present is attributed to the shallow tillage and regular fallow periods while very few introduced (non-native plants) were found. It is also interesting to note that several endemic and rare species were also found within the relevés. The floristic spectrum of these systems is considered typical of the Moroccan flora. The authors conclude that these traditional agroecosystem practices fulfil the criteria of high nature value agriculture. However, should these traditional agroecosystem practices be abandoned in favour of intensive yield-maximizing agriculture, the various segetal species still present, many of which are rare and endemic, will decline necessitating the implementation of policies to ensure that these practices are maintained.

Western Africa

Assédé et al. (2023) conducted a syntaxonomic analysis of plant associations along different soil types in the Biosphere Reserve Pendjari (BRP) within the Sudanian zone of Benin. A total of 202 phytosociological relevés were sampled according to the Braun-Blanquet approach. The numerical analysis included Detrended Correspondence Analysis through which vegetation patterns were sought. A total of 249 plant species were identified and classified into two major groups belonging to eleven associations all correlated with a moisture gradient along a dryland and wetland continuum. The dryland group being a mixture of woodland and shrub savanna associations was found on rocky and gravelly soils (*Burkeo africanae*-*Detarium microcarpi* and *Andropogono gayani*-*Combretum glutinosi*) and on soils associated with or without fine gravels (*Andropogono gayani*-*Terminalietum avicennoidis*, *Andropogono gayani*-*Senegalieta dudgeonii* and *Terminalietum leiocarpae*). The wetland group was characterized by riparian forest associations on sandy-clay soils (*Coletum laurifoliae*, *Borassetum aethiopi* and *Hyparrhenio glabriusculae*-*Mitragyneta inermis*) and floodplain associations (*Terminalia macropterae*-*Mitragyneta inermis*, *Brachiario jubatae*-*Terminalietum macropterae*, *Sorghastro bipennati*-*Vachellietum hockii*) on silt-clay soils. The authors concluded that soil moisture was a key determinant of plant species establishment and thus the development of plant communities.

Ayeko et al. (2023) studied land cover change in inselbergs and adjacent areas from 2003 to 2018 in a region

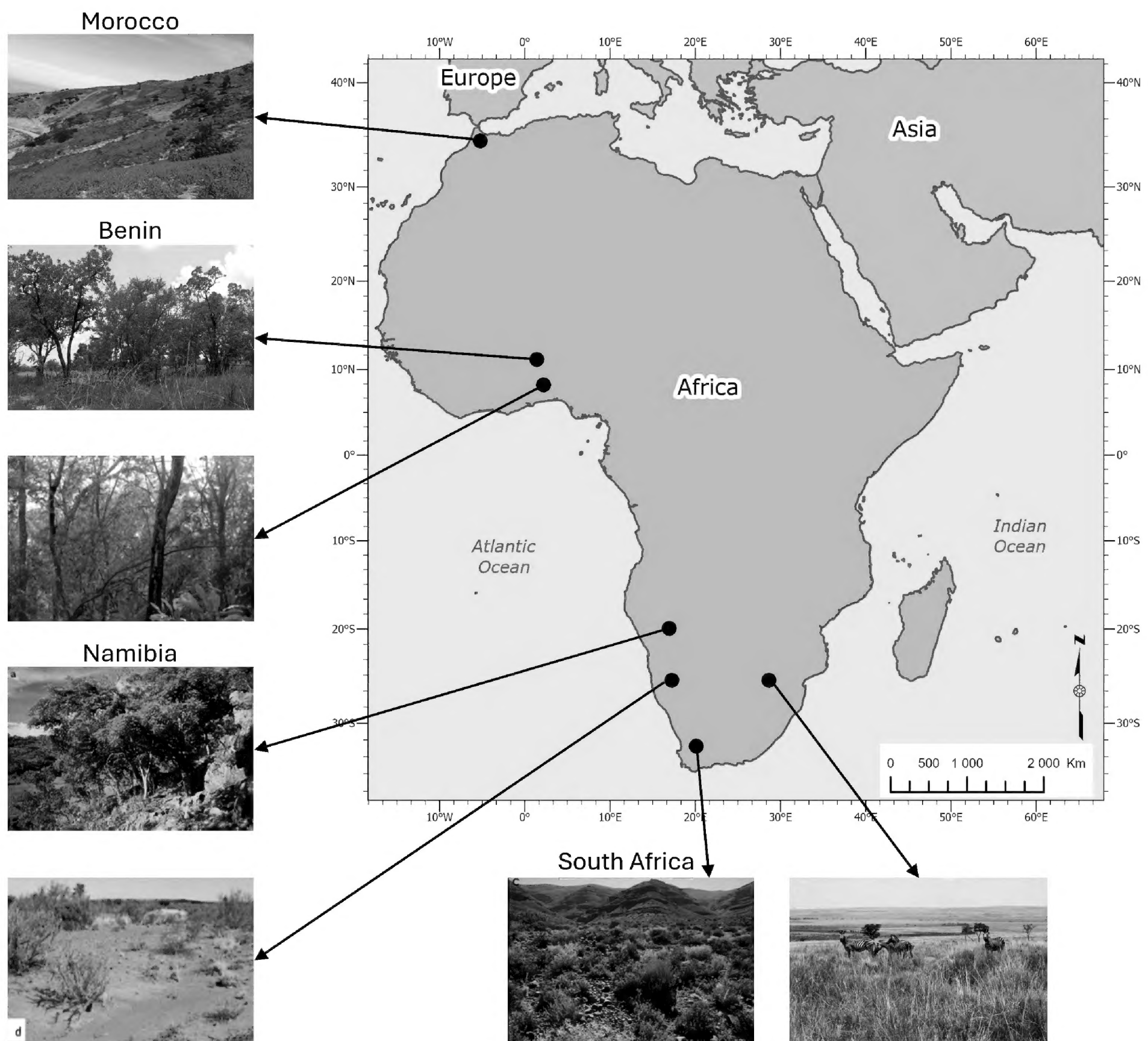


Figure 1. Spatial distribution of the seven articles in the Special Collection "African vegetation studies". The photos stem from the seven studies: Assédé et al. (2023), Ayeko et al. (2023), Brown et al. (2022), Chakkour et al. (2023), Naftal et al. (2024), Samuels et al. (2023) and Strohbach and Strohbach (2023).

of Benin under anthropogenic pressure, with the aim of assessing dynamics and preserving rare endemic species. The authors used supervised classification of Sentinel-2 and Spot-5 satellite images of inselbergs and adjacent areas at 10-m spatial resolution to analyse different land use land cover classes. Savanna, grassland, field, fallow and plantation areas increased between 2003 and 2018. The results indicate a rapid conversion of natural vegetation in inselbergs and adjacent areas into human-made landscapes, a situation that calls for urgent conservation planning.

Southern Africa

Brown et al. (2022) provide a classification of the vegetation of the Telperion Nature Reserve located within the grassland biome of South Africa. As the second largest biome in southern Africa, grasslands have a high diversity of

plants and animals that provide various ecosystem services. The authors provide a detailed description of the different plant communities based on their characteristic species, environmental factors, animal utilization, and topography. Based on 294 relevés, a total of 22 plant communities were identified, grouped into five major communities. The rocky woodland and the mid-plateau grasslands had the highest diversity while a total of 551 different plant species representing 107 plant families were found to be present within the reserve. The study shows that the reserve is a reservoir of plant species making it an important conservation area. This study provides valuable information to enable the management to implement a science-based management plan for the reserve to ensure the long-term functioning and conservation of these grassland ecosystems.

Naftal et al. (2024) used Random Forest models to predict the effect of changing climatic conditions along a south-north rainfall gradient on vegetation within

Namibia. Using 1,986 relevés, the authors classified the vegetation along the gradient into twelve vegetation units. To predict the potential changes in the vegetation composition of these units in 2080, the distribution of the different vegetation classes was modelled using the main climate variables. The results obtained were compared with those of the existing classifications while the model obtained a prediction accuracy of 82%. The results indicate that there will be a higher dominance of broad-leaved and degraded thornbush savannas while units of specific environmental conditions such as the mountain savannas, dwarf shrub savannas and dry thornbush savannas will decrease in area or even disappear. The paper was the Editors' Choice for the second quarter of 2024, for its unique approach of modelling the distribution of vegetation units rather than individual species under future climate conditions.

Samuels et al. (2023) studied three major vegetation types (based on Mucina and Rutherford 2006) along an elevation gradient in the Tankwa Karoo National Park of the arid winter rainfall region of South Africa. The elevation gradient ranged from the lowland plains (338 m a.s.l.) to the escarpment (1147 m a.s.l.). Each vegetation type was sampled at 13–15 sites with 4 m × 100 m linear transects. The authors compared structural and floristic composition, species diversity measures and environmental variables among the three vegetation types. The elevation gradient was identified as a complex gradient that included climatic variables (e.g., increasing aridity with decreasing elevation), soil nutrient and water infiltration status and grazing distribution. Vegetation types were clearly distinguishable in terms of species composition and environmental variables with the strongest separation between the plain and the two upland habitats. Large variations in vegetation variables within the vegetation types were associated with even small variations in environmental variables across the landscape. The study thus concludes that elevation is an important driver of species composition in this system but that, even within vegetation types, environmental variables such as slope and rockiness can result in different states of the vegetation condition.

Strohbach and Strohbach (2023) provide a comprehensive syntaxonomic description of the Karstveld vegetation in Namibia. Based on 889 relevés of 1000 m² extracted from the Phytosociological Database of Namibia, the authors distinguished four main vegetation types using TWINSpan: wetlands and associated grasslands, transitional vegetation between Thornbush savanna and Karstveld, Kalahari type sandy vegetation and true Karstveld vegetation types. Each major vegetation type was further subdivided into more detailed plant communities, 17 of which have been formally described as new plant associations. All associations are clearly defined by diagnostic species. The authors described the true Karstveld vegetation as a new phytosociological class *Terminalietea prunoides*, with eight associations, two new orders and three new alliances. The description of these vegetation units was completed with a comparison of their structure and diversity and with an intuitive visualization of catenas representing their position along topographic gradients. A concluding remark of the authors concerns the high species richness of this

region, which is seriously threatened in some areas that are not protected within the Etosha National Park or private nature reserves and conservancies. This study is outstanding because formal syntaxonomic vegetation classification is still rare in Africa as a whole and mostly restricted to the francophone parts of North Africa. Accordingly, it received the Editors' Award of VCS in 2023 (Dengler et al. 2024).

Conclusions and future perspectives

The above review, though certainly not comprehensive and regionally biased, demonstrates that the scientific knowledge of the vegetation of Africa is still extremely incomplete. Continental overviews are very coarse and not particularly up to date. Only a few countries have a comprehensive overview of the vegetation types on their territory, namely Morocco (Fennane 2003) and South Africa, Lesotho and Eswatini (Mucina and Rutherford 2006). In some others, comprehensive regional overviews have been published, such as for Tenerife in the Canary Islands (Rivas-Martínez et al. 1993) or for the Sinai Peninsula in Egypt (Hatim et al. 2021), but beyond that only local studies or studies focused on specific vegetation types exist. The situation is aggravated by the wide variety of methodological approaches used. Furthermore, there is a certain reluctance on the part of African researchers to use formalized phytosociological names for their units according to the International Code of Phytosociological Nomenclature (ICPN; Theurillat et al. 2021). The EcoVeg approach, invented in the United States (Faber-Langendoen et al. 2018), seems to be even less used in Africa than the phytosociological approach. In this respect, the seven papers we were able to collect for this Special Collection are not much more than a drop in the ocean. It is also significant that we received contributions from only four countries in three of the major regions of Africa. Nevertheless, together with some other recent classification papers from different African countries and the growing African vegetation plot databases contributing to sPlot, this Special Collection marks a positive development.

We believe that the African Section of the International Association for Vegetation Science (https://www.iavs.org/page/working-groups_africa-section) could play an important role in this regard. To move forward, we consider the following aspects to be crucial:

- To increase the exchange and collaboration between vegetation scientists in the different African countries.
- To use the broad expertise available in IAVS to train African vegetation scientists to implement an Africa-wide sampling approach, to create and manage vegetation databases, and to conduct and publish vegetation classification studies.
- To raise the awareness of a vegetation typology derived from vegetation-plot data being essential for land management and biodiversity conservation.

What can be achieved by a few decades of cross-country cooperation among the vegetation scientists of an entire continent, even in the absence of major funding, can be seen in Europe. There, a few visionary scientists founded the European Vegetation Survey (EVS), like the African Section a subgroup of the IAVS (Mucina et al. 1993). There has been a regular exchange in annual meetings, which has now led to numerous useful and influential products, of which only the most prominent ones are highlighted here: (a) Bohn et al. (2004) produced a rather detailed map of the potential natural vegetation of the continent. (b) Chytrý et al. (2016) launched the European Vegetation Archive (EVA), an integrative vegetation plot database, which now contains more than 2 million plots and has led to numerous high-impact papers. (c) Mucina et al. (2016) published the first comprehensive syntaxonomic overview of the continent's high-rank syntaxa (alliances, orders, classes). (d) Janssen et al. (2016) published the first continent-wide Red List of habitat types, largely based on vegetation typology. (e) Chytrý et al. (2020) released an electronic expert system for the automatic/reproducible classification of vegetation plots into the European system of habitat types (EUNIS). (f) In 2023, no less than three ecological indicator value systems for the vascular plants of Europe were released (Dengler et al. 2023; Midolo et al. 2023; Tichý et al. 2023), which now allow a consistent bioindication across the continent. (g) More recently, also ReSurveyEurope, a database of plots repeatedly sampled over time, has been published as an important source for global change studies (Knollová et al. 2024).

This view of the neighbouring continent does not suggest that Africa should do everything in the same way. Obviously, Africa is a much larger continent and, as mentioned above, currently has far fewer financial resources than Europe. On the other hand, we now have much more advanced IT tools (shared documents in the cloud, large databases, powerful modelling techniques, remote sensing, artificial intelligence) available than at the start of EVS. In addition, African scientists have the advantage of learning what has worked in Europe and what has proved to be a drawback in development.

References

- Abutaha MM, El-Khouly AA, Jürgens N, Oldeland J (2020) Plant communities and their environmental drivers on an arid mountain, Gebel Elba, Egypt. *Vegetation Classification and Survey* 1: 21–36. <https://doi.org/10.3897/VCS/2020/38644>
- Adepoju P (2022) Africa's future depends on government-funded R&D. *Nature Africa*. 25 September 2022. <https://doi.org/10.1038/d44148-022-00134-4>
- Alvarez M (2017) Classification of aquatic and semi-aquatic vegetation in two East African sites: Cocktail definitions and syntaxonomy. *Phytocoenologia* 47: 345–364. <https://doi.org/10.1127/phyto/2017/0078>
- Alvarez M, Curran M, Malombe I (2021) SWEA-Dataveg: A vegetation database for sub-Saharan Africa. *Vegetation Classification and Survey* 2: 59–63. <https://doi.org/10.3897/VCS/2021/64911>

Aiming for methodological standardization at an early stage, rather than reinventing the wheel, would certainly allow things to be done faster and more efficiently than in Europe. The BIOTA approach developed for Africa could provide some elements (Jürgens et al. 2012). A common plot database (EVA; Chytrý et al. 2016) has certainly been one of the cornerstones of the success in Europe. Why should we not be visionary and aim for an African Vegetation Archive (AVA)? There have been some attempts like TAVA (Tropical African Vegetation Archive; see Bruelheide et al. 2019) or SWEA-Dataveg (vegetation database for sub-Saharan Africa; Alvarez et al. 2021), but so far, they could not gain the momentum of EVA, either because of the lack of funding or because many researchers in Africa still focus on regional to national perspectives. Finally, publishing of classification results internationally rather than in regional journals or in grey reports can be very beneficial: (i) it rewards the authors with visibility and citations; (ii) it can motivate others to conduct similar studies; and (iii) it can contribute to a gradual harmonization of approaches. VCS would be pleased to be the publication venue for many of the forthcoming studies.

Author contributions

RTG and LB planned the outline with major inputs by JD. All authors contributed to portions of the draft, improved and approved the manuscript.

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- Assédé ESP, Biaou SSH, Orou H, Oumorou M, Geldenhuys CJ, Chirwa PW, Sinsin B (2023) Ecological and structural differentiation of the Sudanian woodlands in the Biosphere Reserve of Pendjari, Benin. *Vegetation Classification and Survey* 4: 139–165. <https://doi.org/10.3897/VCS.91126>
- Ayeko RED, Toyi SSM, Assogbadjo AE, Sinsin BA (2023) Dynamics of inselberg landscapes and their adjacent areas in the Sudano-Guinean zone of Benin through remote sensing analysis. *Vegetation Classification and Survey* 4: 189–202. <https://doi.org/10.3897/VCS.89746>
- Barret AS, Berruti SM, Brown LR (2024) A phytosociological study of the Afromontane vegetation of the Hlogoma Mountain, KwaZulu-Natal, South Africa. *Phytocoenologia* [in press]. <https://doi.org/10.1127/phyto/2024/0445>

- Barthelemy Y, Patrice S, Salifou T, Jeanne MR, Victor H (2015) Floristic diversity of *Piliostigma* associations in relation to latitudinal gradient, soil and climate variables in Burkina Faso, West Africa. *Tropical Ecology* 56: 57–76.
- Behn K, Alvarez M, Mutebi S, Becker M (2022) Vegetation diversity in East African wetlands: Cocktail algorithms supported by a vegetation-plot database. *Phytocoenologia* 51: 199–219. <https://doi.org/10.1127/phyto/2022/0392>
- Bezuidenhout H (1993) Syntaxonomy and synecology of western Transvaal grasslands. Ph.D thesis, University of Pretoria, Pretoria, ZA.
- Bezuidenhout H, Brown LR (2021) Mountain Zebra National Park phytosociological classification: A case study of scale and management in the Eastern Cape, South Africa. *South African Journal of Botany* 138: 227–241. <https://doi.org/10.1016/j.sajb.2020.12.017>
- Bohn U, Gollub G, Hettwer C, Neuhäuslová Z, Raus T, Schlüter H, Weber H, Hennekens S (2004) Map of the natural vegetation of Europe: Scale 1 : 2 500 000. Interactive CD-ROM: explanatory text, legend, maps. Bundesamt für Naturschutz, Bonn, DE.
- Brand RF, Du Preez PJ, Brown LR (2009) A classification and description of the shrubland vegetation on Platberg, Eastern Free State, South Africa. *Koedoe* 51: e696. <https://doi.org/10.4102/koedoe.v51i1.696>
- Brand RF, Brown LR, Du Preez PJ (2011) The grassland vegetation of Platberg, eastern Free State, South Africa. *Koedoe* 53: e1027. <https://doi.org/10.4102/koedoe.v53i1.1027>
- Brown LR, Bredenkamp GJ (2018) An overview of the vegetation classification approach in South Africa. *Phytocoenologia* 48: 163–170. <https://doi.org/10.1127/phyto/2017/0163>
- Brown LR, Bredenkamp GJ, Van Rooyen N (1997) Phytosociological synthesis of the vegetation of the Borakaklao Nature reserve, North-west Province. *South African Journal of Botany* 63: 242–253. [https://doi.org/10.1016/S0254-6299\(15\)30761-4](https://doi.org/10.1016/S0254-6299(15)30761-4)
- Brown LR, Magagula IP, Barrett AS (2022) A vegetation classification and description of Telperion Nature Reserve, Mpumalanga, South Africa. *Vegetation Classification and Survey* 3: 199–219. <https://doi.org/10.3897/VCS.85209>
- Bruehlheide H, Dengler J, Jiménez-Alfaro B, Purschke O, Hennekens SM, Chytrý M, Pillar VD, Jansen F, Kattge J, ... Zverev A (2019) sPlot – A new tool for global vegetation analyses. *Journal of Vegetation Science* 30: 161–186. <https://doi.org/10.1111/jvs.12710>
- Chakkour S, Bergmeier E, Meyer S, Kassout J, Kadiri M, Ater M (2023) Plant diversity in traditional agroecosystems of North Morocco. *Vegetation Classification and Survey* 4: 31–45. <https://doi.org/10.3897/VCS.86024>
- Christie R (2019) African science: Better but still inadequate. *South African Journal of Science* 115: e6233. <https://doi.org/10.17159/sajs.2019/6233>
- Cilliers SS, Bredenkamp GJ (1998) Vegetation analysis of railway reserves in the Potchefstroom municipal area, North West Province, South Africa. *South African Journal of Botany* 64: 271–280. [https://doi.org/10.1016/S0254-6299\(15\)30900-5](https://doi.org/10.1016/S0254-6299(15)30900-5)
- Cilliers SS, Bredenkamp GJ (1999a) Analysis of the spontaneous vegetation of intensively managed urban open space in the Potchefstroom Municipal Area, North West Province, South Africa. *South African Journal of Botany* 65: 59–68. [https://doi.org/10.1016/S0254-6299\(15\)30940-6](https://doi.org/10.1016/S0254-6299(15)30940-6)
- Cilliers SS, Bredenkamp GJ (1999b) Ruderal and degraded natural vegetation on vacant lots in the Potchefstroom Municipal Area, North West Province, South Africa. *South African Journal of Botany* 65: 163–173. [https://doi.org/10.1016/S0254-6299\(15\)30956-X](https://doi.org/10.1016/S0254-6299(15)30956-X)
- Chytrý M, Hennekens SM, Jiménez-Alfaro B, Knollová I, Dengler J, Jansen F, Landucci F, Schaminée JHJ, Aćić S, ... Yamalov S (2016) European Vegetation Archive (EVA): an integrated database of European vegetation plots. *Applied Vegetation Science* 19: 173–180. <https://doi.org/10.1111/avsc.12191>
- Chytrý M, Tichý L, Hennekens SM, Knollová I, Janssen JAM, Rodwell JS, Peterka T, Marcenò C, Landucci F, ... Schaminée JHJ (2020) EUNIS Habitat Classification: Expert system, characteristic species combinations and distribution maps of European habitats. *Applied Vegetation Science* 23: 648–675. <https://doi.org/10.1111/avsc.12519>
- Deil U, Alvarez M, Hemp A (2016) Amphibious vegetation in the Afro-Alpine belt and the role of cryoturbation in creating regeneration niches. In: Box EO (Ed.) *Vegetation structure and function at multiple spatial, temporal and conceptual scales*. Springer, Cham, CH, 315–330. https://doi.org/10.1007/978-3-319-21452-8_12
- Dengler J, Jansen F, Glöckler F, Peet RK, De Cáceres M, Chytrý M, Ewald J, Oldeland J, Lopez-Gonzalez G, ... Spencer N (2011) The Global Index of Vegetation-Plot Databases (GIVD): a new resource for vegetation science. *Journal of Vegetation Science* 22: 582–597. <https://doi.org/10.1111/j.1654-1103.2011.01265.x>
- Dengler J, Jansen F, Chusova O, Hüllbusch E, Nobis MP, Van Meerbeek K, Axmanová I, Bruun HH, Chytrý M, ... Gillet F (2023) Ecological Indicator Values for Europe (EIVE) 1.0. *Vegetation Classification and Survey* 4: 7–29. <https://doi.org/10.3897/VCS.98324>
- Dengler J, Biurrun I, Jansen F, Willner W (2024) Vegetation Classification and Survey is performing well. *Vegetation Classification and Survey* 5: 1–10. <https://doi.org/10.3897/VCS.118454>
- Faber-Langendoen D, Baldwin K, Peet RK, Meidinger D, Muldavin E, Keeler-Wolf T, Josse C (2018) The EcoVeg approach in the Americas: U.S., Canadian and international vegetation classifications. *Phytocoenologia* 48: 215–237. <https://doi.org/10.1127/phyto/2017/0165>
- Fennane M (2003) Inventaire des communautés végétales à l'aide du phytosociologue, au Maroc. *Ecologia Mediterranea* 29: 87–106. <https://doi.org/10.3406/ecmed.2003.1531>
- Fujiwara K, Furukawa T, Kiboi SK, Mathenge S, Chalo Mutiso PB, Hayashi H, Meguro S (2014) Forest types and biodiversity around the Great Rift Valley in Kenya. *Contribuții Botanice* 49: 143–178.
- Fungomeli M, Githitho A, Frasaroli F, Chidzinga S, Cianciaruso M, Chiarucci A (2020) A new Vegetation-Plot Database for the Coastal Forests of Kenya. *Vegetation Classification and Survey* 1: 19–35. <https://doi.org/10.3897/VCS/2020/47180>
- Giess W (1971) A preliminary vegetation map of South West Africa. *Dinteria* 4: 5–14.
- Gnoumou A, Salfo S, Thiombiano A (2020) Woody plant communities of Comoe-Leraba reserve: Characterisation and impact of soils on their distribution. *International Journal of Biological and Chemical Sciences* 14: 3168–3187. <https://doi.org/10.4314/ijbcs.v14i9.16>
- Hahn-Hadjali K, Wittig R, Schmidt M, Zizka G, Thiombiano A, Sinsin B (2010) Vegetation of West Africa. In: Thiombiano A, Kampmann D (Eds) *Biodiversity Atlas of West Africa. Volume II: Burkina Faso*. UICN Burkina Faso, Ougadougou, BF, 78–85.
- Hatim MZ, Janssen JAM, Pätsch P, Shaltout K, Schaminée JHJ (2021) Phytosociological survey of the desert vegetation of Sinai, Egypt. *Applied Vegetation Science* 24: e12627. <https://doi.org/10.1111/avsc.12627>
- Jansen F, Bergmeier E, Dengler J, Janišová M, Krestov P, Willner W (2016) Vegetation classification: a task of our time. *Phytocoenologia* 46: 1–4. <https://doi.org/10.1127/phyto/2016/0134>

- Janssen JAM, Rodwell JS, Garcia Criado M, Gubbay S, Haynes T, Nieto A, Sanders N, Landucci F, Loidi J, ... Valachovič M (2016) European Red List of Habitats – Part 2. Terrestrial and freshwater habitats. European Union, Luxembourg, LU, 38 pp.
- Jürgens N, Schmiedel U, Haarmeyer DH, Dengler J, Finckh M, Goetze D, Gröngroft A, Hahn K, Koulibaly A, ... Zizka G (2012) The BIOTA Biodiversity Observatories in Africa – a standardized framework for large-scale environmental monitoring. *Environmental Monitoring and Assessment* 184: 655–678. <https://doi.org/10.1007/s10661-011-1993-y>
- Jürgens N, Oldeland J, Hachfeld B, Erb E, Schultz C (2013) Ecology and spatial patterns of large-scale vegetation units within the central Namib Desert. *Journal of Arid Environments* 93: 59–79. <https://doi.org/10.1016/j.jaridenv.2012.09.009>
- Kay C, Bredenkamp GJ, Theron GK (1993) The plant communities of the Golden Gate Highlands National Park in the north-eastern Orange Free State. *South African Journal of Botany* 59: 442–449. [https://doi.org/10.1016/S0254-6299\(16\)30717-7](https://doi.org/10.1016/S0254-6299(16)30717-7)
- Knollová I, Chytrý M, Bruelheide H, Dullinger S, Jandt U, Bernhardt-Römermann M, Biurrun I, De Bello F, Glaser M, ... Essl F (2024) ReSurveyEurope: a database of resurveyed vegetation plots in Europe. *Journal of Vegetation Science* 35: e13235. <https://doi.org/10.1111/jvs.13235>
- Krishna VV (2020) Open science and its enemies: challenges for a sustainable science–society social contract. *Journal of Open Innovation: Technology, Market, and Complexity* 6: e61. <https://doi.org/10.3390/joitmc6030061>
- Küper W, Sommer JH, Lovett JC, Barthlott W (2006) Deficiency in African plant distribution data – missing pieces of the puzzle. *Botanical Journal of the Linnean Society* 150: 355–368. <https://doi.org/10.1111/j.1095-8339.2006.00494.x>
- La Ferla B, Taplin J, Ockwell D, Lovett JC (2002) Continental scale patterns of biodiversity: can higher taxa accurately predict African plant distributions? *Botanical Journal of the Linnean Society* 138: 225–235. <https://doi.org/10.1046/j.1095-8339.2002.138002225.x>
- Lebrun J (1947) Exploration du Parc National Albert. Mission J. Lebrun (1937–1938). 1. La Végétation de la plaine alluviale au sud du Lac Édouard. Institut des Parcs Nationaux du Congo Belge, Bruxelles, BE.
- Linder HP (1998) Numerical analyses of African plant distribution patterns. In: Huxley CR, Lock JM, Cutler DF (Eds) *Chorology, taxonomy and ecology of the floras of Africa and Madagascar*. Royal Botanic Gardens, Kew, UK, 67–86.
- Linder HP (2001) Plant diversity and endemism in sub-Saharan tropical Africa. *Journal of Biogeography* 28: 169–182. <https://doi.org/10.1046/j.1365-2699.2001.00527.x>
- Linder HP, Lovett JC, Mutke J, Barthlott W, Jürgens N, Rebelo T, Küper W (2005) A numerical re-evaluation of the sub-Saharan Phytochoria of mainland Africa. *Biologische Skrifter* 55: 229–252.
- Loidi J, Navarro-Sánchez G, Vynokurov D (2022) Climatic definitions of the world's terrestrial biomes. *Vegetation Classification and Survey* 3: 231–271. <https://doi.org/10.3897/VCS.86102>
- Lori T, Dithlogo MK, Setshogo MP, Koosaletse-Mswela P (2019) Classification, description and mapping of the vegetation in Khutse Game Reserve, Botswana. *Botswana Journal of Agriculture and Applied Sciences* 13: 8–23. <https://doi.org/10.37106/bojaas.2019.45>
- Lovett JC, Rudd S, Taplin J, Frimodt-Møller C (2000) Patterns of plant diversity in Africa south of the Sahara and their implications for conservation management. *Biodiversity and Conservation* 9: 37–46. <https://doi.org/10.1023/A:1008956529695>
- Luther-Mosebach J, Dengler J, Schmiedel U, Röwer IU, Labitzki T, Gröngroft A (2012) A first formal classification of the Hardeveld vegetation in Namaqualand, South Africa. *Applied Vegetation Science* 15: 401–431. <https://doi.org/10.1111/j.1654-109X.2011.01173.x>
- Marcenò C, Guarino R, Loidi J, Herrera M, Isermann M, Knollová I, Tichý L, Tzonev RT, Acosta ATR, ... Chytrý M (2018) Classification of European and Mediterranean coastal coastal dune vegetation. *Applied Vegetation Science* 21: 533–559. <https://doi.org/10.1111/avsc.12379>
- Marcenò C, Guarino R, Mucina L, Biurrun I, Deil U, Shaltout K, Finckh M, Font X, Loidi J (2019) A formal classification of the *Lygeum spartum* vegetation of the Mediterranean Region. *Applied Vegetation Science* 22: 593–608. <https://doi.org/10.1111/avsc.12456>
- Marshall CAM, Wieringa JJ, Hawthorne WD (2021) An interpolated biogeographical framework for tropical Africa using plant species distributions and the physical environment. *Journal of Biogeography* 48: 23–36. <https://doi.org/10.1111/jbi.13976>
- Mayaux P, Bartholome E, Eva H, Massart M, Van Cutsem C, Cabral A, Nonguierma A, Diallo O, Pretorius C, ... Belward A (2003) A land cover map of Africa. EUR 20665 EN. European Commission, Brussels, BE.
- McClellan C, Lovett JC, Küper W, Hannah L, Sommer JH, Barthlott W, Termansen M, Smith GF, Tokumine S, Taplin J (2005) African plant diversity and climate change. *Annals of the Missouri Botanical Garden* 92: 139–152.
- Mengist W (2020) An overview of the major vegetation classification in Africa and the new vegetation classification in Ethiopia. *American Journal of Zoology* 2: 51–62.
- Midolo G, Herben T, Axmanová I, Marcenò C, Pätsch R, Bruelheide H, Karger DN, Aćić S, Bergamini A, ... Chytrý M (2023) Disturbance indicator values for European plants. *Global Ecology and Biogeography* 32: 24–34. <https://doi.org/10.1111/geb.13603>
- Morgenthal TL, Cilliers SS (1999) Vegetation analysis of Pedlar's Bush, Mpumalanga, and its conservation. *South African Journal of Botany* 65: 270–280. [https://doi.org/10.1016/S0254-6299\(15\)30994-7](https://doi.org/10.1016/S0254-6299(15)30994-7)
- Mucina L, Rutherford MC [Eds] (2006) *The vegetation of South Africa, Lesotho and Swaziland*. South African National Biodiversity Institute, Pretoria, ZA, 816 pp.
- Mucina L, Rodwell JS, Schaminée JHJ, Dierschke H (1993) European Vegetation Survey: Current state of some national programmes. *Journal of Vegetation Science* 4: 429–438. <https://doi.org/10.2307/3235603>
- Mucina L, Bültmann H, Dierßen K, Theurillat JP, Raus T, Čarni A, Šumberová K, Willner W, Dengler J, ... Tichý L (2016) Vegetation of Europe: Hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. *Applied Vegetation Science* 19(Suppl. 1): 3–264. <https://doi.org/10.1111/avsc.12257>
- Murray-Hudson M, Combs F, Wolski P, Brown MT (2011) A vegetation-based hierarchical classification for seasonally pulsed floodplains in the Okavango Delta, Botswana. *African Journal of Aquatic Science* 36: 223–234. <https://doi.org/10.2989/16085914.2011.636904>
- Naftal L, De Cauwer V, Strohbach BJ (2024) Potential distribution of major plant units under climate change scenarios along an aridity gradient in Namibia. *Vegetation Classification and Survey* 5: 127–151. <https://doi.org/10.3897/VCS.99050>
- Quézel P (1956) Contribution à l'étude des forêts de chênes à feuilles caduques d'Algérie. *Mémoires de la Société d'histoire naturelle de l'Afrique du Nord* N.S. 1: 1–57.
- Quézel P, Barbero M (1981) Contribution à l'étude des formations pré-steppiques à genévriers au Maroc. *Boletim da Sociedade Broteriana* 253: 1137–1160.

- Quézel P, Barbero M (1986) Aperçu syntaxonomique sur la connaissance actuelle de la classe des *Quercetea ilicis* au Maroc. *Ecologia Mediterranea* 12: 105–112. <https://doi.org/10.3406/ecmed.1986.1177>
- Quézel P, Barbero M (1989) Les formations à genévriers rampants du Djurdjura (Algérie). Leur signification écologique, dynamique et syntaxonomique dans une approche globale des cédraies kabyles. *Lazaroa* 11: 85–99.
- Quézel P, Barbero M, Benabid A (1987) Contribution à l'étude des groupements forestiers et pré-forestiers du Haut Atlas oriental (Maroc). *Ecologia Mediterranea* 13: 107–117. <https://doi.org/10.3406/ecmed.1987.1616>
- Quézel P, Barbero M, Benabid A, Loisel R, Rivas-Martínez S (1988) Contribution à l'étude des groupements préforestiers et des matorrals rifains. *Ecologia Mediterranea* 14: 77–122. <https://doi.org/10.3406/ecmed.1988.1208>
- Revermann R, Oldeland J, Gonçalves FM, Luther-Mosebach J, Gomes AL, Jürgens N, Finckh M (2018) Dry tropical forests and woodlands of the Cubango Basin in southern Africa - First classification and assessment of their woody species richness. *Phytocoenologia* 48: 23–50. <https://doi.org/10.1127/phyto/2017/0154>
- Rivas-Martínez S, Wildpret de la Torre W, Arco Aguilar M, Rodríguez O, Pérez de Paz PL, García-Gallo A, Acebes Ginovés JR, Díaz González TE, Fernández-González F (1993) La comunidades vegetales de la Isla de Tenerife (Islas Canarias). *Itinera Geobotanica* 7: 169–374.
- Samuels MI, Saaed M, Jacobs S, Masubelele ML, van der Merwe H, Khomo L (2023) Vegetation structure and composition at different elevational intervals in the arid Tankwa Karoo National. *Vegetation Classification and Survey* 4: 115–126. <https://doi.org/10.3897/VCS.86310>
- Sianga K, Fynn R (2017) The vegetation and wildlife habitats of the Savuti-Mababe-Linyanti ecosystem, northern Botswana. *Koedoe* 59: a1406. <https://doi.org/10.4102/koedoe.v59i2.1406>
- Strohbach B, Jürgens N (2010) Towards a user-friendly vegetation map of Namibia: Ground truthing approach to vegetation mapping. In: Schmiedel U, Jürgens N (Eds) *Biodiversity in southern Africa. Volume 2: Patterns and processes at regional scale*. Hess Publisher, Göttingen, DE, 46–56.
- Strohbach BJ, Strohbach MM (2023) A first syntaxonomic description of the vegetation of the Karstveld in Namibia. *Vegetation Classification and Survey* 4: 241–284. <https://doi.org/10.3897/VCS.99045>
- Theurillat JP, Willner W, Fernández-González F, Bültmann H, Carni A, Gigante D, Mucina L, Weber H (2021) *International Code of Phytosociological Nomenclature*. 4th ed. *Applied Vegetation Science* 24: e12491. <https://doi.org/10.1111/avsc.12491>
- Tichý L, Axmanová I, Dengler J, Guarino R, Jansen F, Midolo G, Nobis MP, Van Meerbeek K, Aćić S, ... Chytrý M (2023) Ellenberg-type indicator values for European vascular plant species. *Journal of Vegetation Science* 34: e13168. <https://doi.org/10.1111/jvs.13168>
- Tindano EG, Kaboré E, Porembski S, Thiombiano A (2024) Plant communities on inselbergs in Burkina Faso. *Heliyon* 10: e23653. <https://doi.org/10.1016/j.heliyon.2023.e23653>
- Tsheboeng G, Murray-Hudson M, Kashe K (2016) A baseline classification of riparian woodland plant communities in the Okavango Delta, Botswana. *Southern Forests* 78: 97–104. <https://doi.org/10.2989/20702620.2015.1108619>
- Van der Merwe H, Van Rooyen MW, Van Rooyen N (2008a) Vegetation of the Hantam-Tanqua-Roggeveld subregion, South Africa. Part 1: Fynbos Biome related Vegetation. *Koedoe* 50: 61–71. <https://doi.org/10.4102/koedoe.v50i1.130>
- Van der Merwe H, Van Rooyen MW, Van Rooyen N (2008b) Vegetation of the Hantam-Tanqua-Roggeveld subregion, South Africa. Part 2: Succulent Karoo Biome related vegetation. *Koedoe* 50: 160–182. <https://doi.org/10.4102/koedoe.v50i1.148>
- Van Staden P, Bredenkamp GJ, Bezuidenhout H, Brown LR (2021) A reclassification and description of the Waterberg Mountain vegetation of the Marakele National Park, Limpopo province, South Africa. *Koedoe* 63: a1689. <https://doi.org/10.4102/koedoe.v63i1.1689>
- White F (1983) *The vegetation of Africa. A descriptive memoir to accompany the Unesco/AETF/UNSO vegetation map of Africa*. Orstom-Unesco, Paris, FR, 356 pp.
- World Bank (2020) World Bank open data. <https://datos.bancomundial.org/indicador/GB.XPD.RSDV.GD.ZS?locations=ZJ-XU-EU> [accessed 30 Jun 2024]
- Zerbo I, Bernhardt-Römermann M, Ouédraogo O, Hahn K, Thiombiano A (2018) Diversity and occurrence of herbaceous communities in West African savannas in relation to climate, land use and habitat. *Folia Geobotanica* 53: 17–39. <https://doi.org/10.1007/s12224-017-9303-2>

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